EARLIEST EVIDENCE OF DINOSAURS FROM CENTRAL GONDWANA

M.A. RAATH

Raath, M.A. 1996 12 20: The earliest evidence of dinosaurs from central Gondwana. *Memoirs of the Queensland Museum* **39**(3): 703-709. Brisbane. ISSN 0079-8835.

Rocks of the Elliot Formation and its regional equivalents in southern Africa, which straddle the Triassic-Jurassic boundary, have traditionally been regarded as the earliest dinosaur-bearing sediments in this region. The identification of tridactyl *Grallator*-like tracks at a site in the Eastern Cape Province, South Africa, and the discovery of an isolated fragment of a prosauropod femur in the central Zambezi Valley of Zimbabwe, both in rocks assigned to equivalents of the underlying Molteno Formation on stratigraphic and palaeobotanical grounds, indicate the presence of an earlier dinosaurian fauna. These traces constitute the earliest known evidence of dinosaurs in this region of Central Gondwana. ☐ *Triassic, dinosaur tracks, rhynchosaur, prosauropod, South Africa, Zimbabwe, Molteno.*

M.A. Raath, Port Elizabeth Museum, Port Elizabeth, South Africa. (Current address: Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg, South Africa); 5 April 1996.

Two fossil discoveries during the last decade in two far-flung localities in southern Africa — Maclear in the north-eastern Eastern Cape Province of South Africa, and the Cabora Bassa Basin of the Central Zambezi Valley of Zimbabwe (Fig. 1) — have yielded evidence of a dinosaur fauna predating that of the Elliot Formation of the Stormberg Group in South Africa (Raath, Kitching, Shone & Rossouw, 1990; Raath, Oesterlen & Kitching, 1992).

The Elliot Formation and its regional equivalents have generally been regarded as the earliest dinosaur-bearing formations in this part of Africa. According to Olsen & Galton (1984) the Elliot spans the Triassic-Jurassic boundary (Carnian to Sinemurian). On the basis of its fossil content in South Africa, Kitching & Raath (1984) recognised two distinct biozones in the Elliot Formation: a lower *Euskelosaurus* Range Zone characterised by the presence of the relatively large prosauropod dinosaur *Euskelosaurus*, accompanied by capitosaurid amphibians, unidentified rauisuchid thecodontians and rare cynodont therapsids. This zone is followed by the *Massospondylus* Range Zone, characterised by the abundance of the smaller prosauropod dinosaur *Massospondylus* and a diverse fauna which includes amphibia, a chelonian, crocodilians, dinosaurs other than prosauropods, therapsids and even rare primitive mammals (Kitching & Raath, 1984).

The discoveries which are the subject of this contribution have only recently come to the attention of scientists, although one of them has been known to the local populace for a long time. From the early years of this century, trout anglers fishing along the Pot River in the vicinity of the town of Maclear (Fig. 1) in the Eastern Cape Province of South Africa have known of the presence of unusual markings in the rocks lining the river's banks, which have long been known locally as 'petrified spoor' (animal tracks). Although these tracks have featured in local newspapers from time to time, they escaped the notice of geologists and palaeontologists. As far as I can determine, ours was the first detailed investigation of the site (Raath et al., 1990). It confirmed that the marks included vertebrate tracks and that animals of probably more than one kind were involved, at least one of them a dinosaur. It was further concluded that the rocks in which the tracks are preserved belong to the Molteno Formation (Raath et al., 1990), which underlies the Elliot Formation.

Until now, no unequivocal evidence of tetrapod vertebrates has been found in Molteno rocks — other than reports by P. Ellenberger of vertebrate tracks of many kinds in Lesotho in beds which he assigned to the Molteno, including tracks of a variety of dinosaurs (see synthesis in Ellenberger, 1970). Persistent doubts about the reliability of these stratigraphic assignments has meant that this work has been largely overlooked. The only unquestionable animal fossils previously recovered from the Molteno have been some palaeoniscid fish (*Semionotus* sp.) and a variety of invertebrates, mainly insects. Anderson & Anderson (1984: 40) state in their summary of Molteno fossils: '*Tetrapods — Bone is not preserved in the Molteno Formation*'.

The early Mesozoic deposits of Zimbabwe are palaeontologically very similar to their South

African counterparts. In that country, the main dinosaur-bearing unit, the Forest Sandstone Formation, contains a typical but rather depauperate 'terminal Karoo fauna' which is dominated by prosauropod and small theropod dinosaurs, like the South African middle and upper Elliot Formation fauna. However, the Zimbabwean fauna lacks many of the other elements represented in South Africa, particularly the ornithischian dinosaurs, advanced therapsids and early mammals.

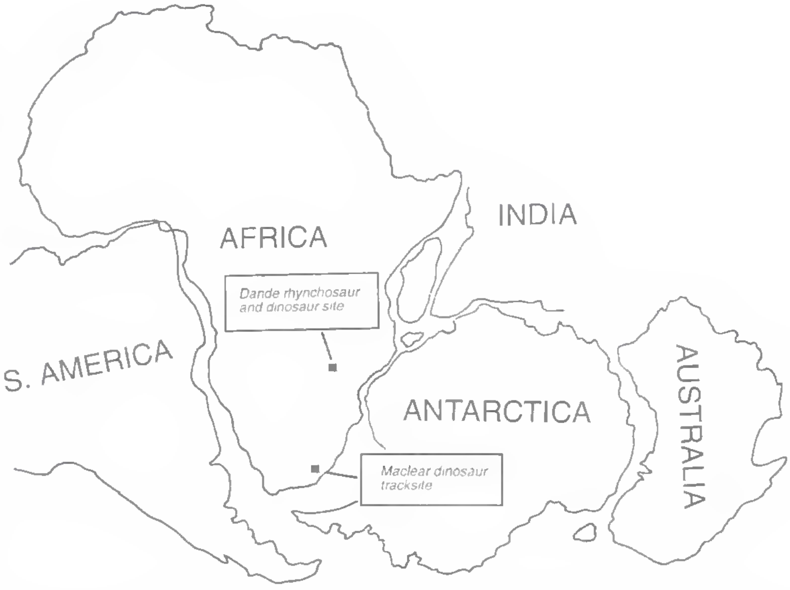
AFRICA
INDIA
Dande rhynchosaur and dinosaur site
S. AMERICA
ANTARCTICA
AUSTRALIA
Maclear dinosaur tracksite

FIG. 1. Reconstruction of Gondwana prior to separation, showing approximate positions of the two localities referred to in the text (modified from Colbert, 1975: fig. 5).

As in South Africa, the Zimbabwean beds which underlie the traditional dinosaur-bearing beds have until now also been considered barren of tetrapods (see e.g., Bond, 1973). The fossils usually associated with these beds in Zimbabwe include silicified logs (cf. *Dadoxylon* spp), particularly from the Pebbly Arkose Formation and plant leaf impressions (mainly the pteridosperm genus *Dicroidium*) and rare invertebrates (freshwater bivalve molluscs) (see summary in Bond, 1973). On the basis of the dominance of the characteristic Triassic fossil plant genus *Dicroidium*, Bond (1973) concluded that these beds in Zimbabwe (including the Pebbly Arkose, the Ripple Marked Flags and the Fine Red Marly Sandstone) were equivalents of the Molteno Formation of the Karoo Supergroup in South Africa (late Triassic: Carnian, Anderson & Anderson, 1984). Some lungfish remains were recovered from beds of this age in Lake Kariba in 1973, and until the recent tetrapod discoveries in the Central Zambezi Valley (Raath, Oesterlen & Kitching, 1992), they were the only vertebrate remains known from these strata in Zimbabwe.

SUMMARY OF THE TWO OCCURRENCES

MACLEAR DINOSAUR TRACKS, SOUTH AFRICA. The most prominent trace in the tracksite at Maclear, Eastern Cape Province, South Africa, is a straight groove ploughed into the mud (Fig. 2a), with other less obvious similar traces nearby. Raath et al. (1990) tentatively interpreted these grooves as the tail drags of quadrupedal dinosaurs, but no clear unequivocal footprints can be associated with them, so this suggestion is doubtful at best. It has been suggested that a more likely interpretation is that they are drag marks from an object floating in the river, although the remarkably detailed preservation of the rolled edges of the groove indicate very low velocity of the current responsible.

On the other hand, the majority of the tracks are clear and well preserved, consisting of plentiful tridactyl footprints of a small bipedal dinosaur (Fig. 2b, c). Similar tracks are well known from a number of other places in southern Africa, especially in Lesotho (Ellenberger, 1970; Olsen & Galton, 1984) and from one locality in Zimbabwe (Raath, 1972). Since publication of the report by Raath et al. (1990), several more reports of similar well-preserved tridactyl dinosaur footprints have been received from the farming districts south and west of Maclear.

Raath et al. (1990) concluded that the tridactyl tracks are assignable either to the ichnogenus *Grallator* (see Olsen & Galton, 1984: fig. 3H) or *Atreipus* (Olsen & Baird, 1986: figs 6.3, 6.4). But *Atreipus* is defined as '*habitually quadrupedal ichnites*' (Olsen & Baird, 1986: 62), and since no manus impressions are associated with any of the tridactyl pes impressions at Maclear, it appears that this ichnogenus can be eliminated. Accord-

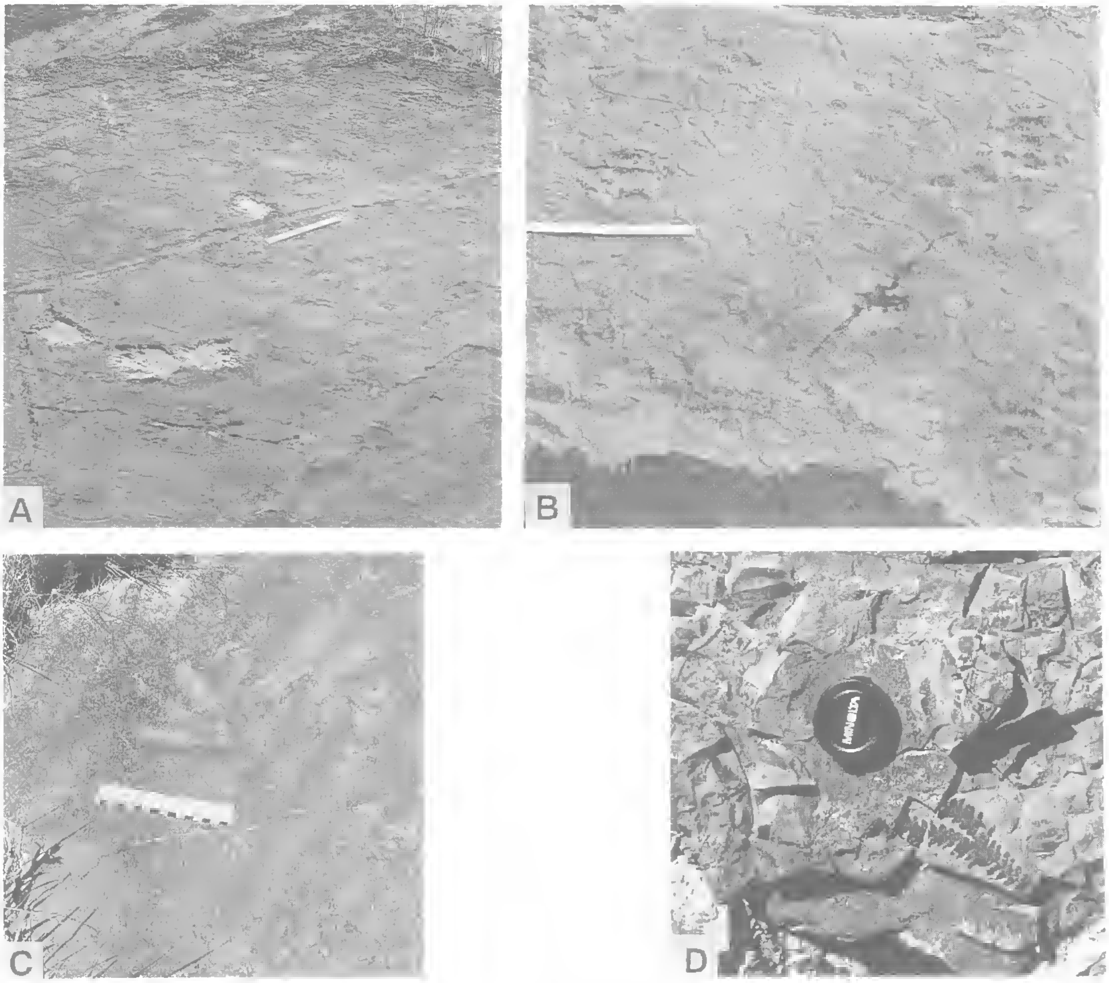

FIG. 2. Maclear dinosaur tracksite. A, the straight ploughed trace — possibly a tail-drag. B, tridactyl prints arranged in several trackways (note the infilled desiccation cracks on the surface). C, single isolated tridactyl print, *Grallator* sp., from a ripple-marked surface. D, frond impression of the pteridosperm genus *Dicroidium* from near the tracksite.

ing to Olsen & Galton (1984: 97), *Grallator*-like tracks were '*almost certainly made by small theropod dinosaurs*', which therefore indicates the presence of small theropods at Maclear when these sediments were laid down.

RHYNCHOSAURS AND DINOSAUR, ZIMBABWE. The rhynchosaur fossils from the Dande Communal Lands in Zimbabwe consist mainly of scattered, isolated, often fragmentary bones and teeth, including the unmistakable tooth-studded maxillary dental plates of these highly specialised herbivorous archosauromorphs (Fig. 3a). They evidently belong to a single rhynchosaur taxon, showing a considerable range in size.

Rhynchosaur taxa are well-known to be useful for dating the beds from which they come (Chatterjee, 1980; Benton, 1983) and the state of the diagnostic dental and other cranial characters in the Zimbabwean rhynchosaurs identifies them as *Hyperodapedon*, of the family Rhynchosauridae, sub-family Hyperodapedontinae (Raath et al., 1992). This has significance for dating the strata from which they come.

The single fragmentary non-rhynchosaur bone found with rhynchosaur material at one of the Dande sites bears the characteristic crest-like fourth trochanter of a prosauropod dinosaur femur (Fig. 3b, c). The fragment is broken off just below the trochanter and most of the head is missing, but enough remains to be reasonably confident of its identification as a prosauropod. Although it is small compared to most of the known southern African prosauropods, such as *Euskelosaurus* and *Massospondylus*, the specimen is taken to be from an adult based on the degree of ossification of scars of minor surface features like the vascular groove running along the anterior surface to the nutritive foramen opposite the fourth trochanter (Fig. 3c).

If this identification is correct, it demonstrates the presence of prosauropod dinosaurs when the Dande beds were laid down.

GEOLOGY AND AGE OF THE TWO OCCURRENCES

MACLEAR TRACKSITE. The Maclear tracks are preserved in a medium-to-finegrained cross-bedded silty sandstone belonging to the Stormberg Group, from somewhere near its base. The Stormberg succession consists of the thick, coarse fluvial sandstones and finer shales of the Molteno Formation at its base, overlain by the brick-red mudrocks and sandstones of the Elliot Formation, which in turn are overlain by the pale, finer-grained, mainly aeolian sandstones of the Clarens Formation. The thick Drakensberg lavas cap the sequence (Fig. 4). This entire sequence is well exposed in the Barkly Pass — a road pass through the Drakensberg mountains just 50km west of the Maclear tracksite. Visser (1984) notes that in this area, the Molteno Formation makes up the valley floor at the base of the Drakensberg mountains. The mountains themselves are made up of Elliot Formation mudrocks at the base, with the pale sandstones of the Clarens Formation above, and capping the sequence on the mountain peaks are the Drakensberg lavas. Visser (cited in Raath et al., 1990) locates the Molteno-Elliot contact '*right at the foot of the (Barkly) pass in the Tsomo River and this position agrees with the boundary defined by (A.L.) du Toit on his map (?1910) of the area.*'.

The Pot River has cut its deep valley through the flat plains at the foot of the mountains — i.e., through Molteno deposits. The beds through which it has cut might be described as 'uppermost Molteno', and one coarse sandstone ledge from this unit overlooks the fossil tracksite about 100m below. This sandstone is lithologically reminiscent of the Indwe Sandstone Member, a persistent and highly characteristic marker horizon in the Molteno Formation, all of which suggests that the fossil tracks are in Molteno beds, substantially below the contact with the Elliot Formation.

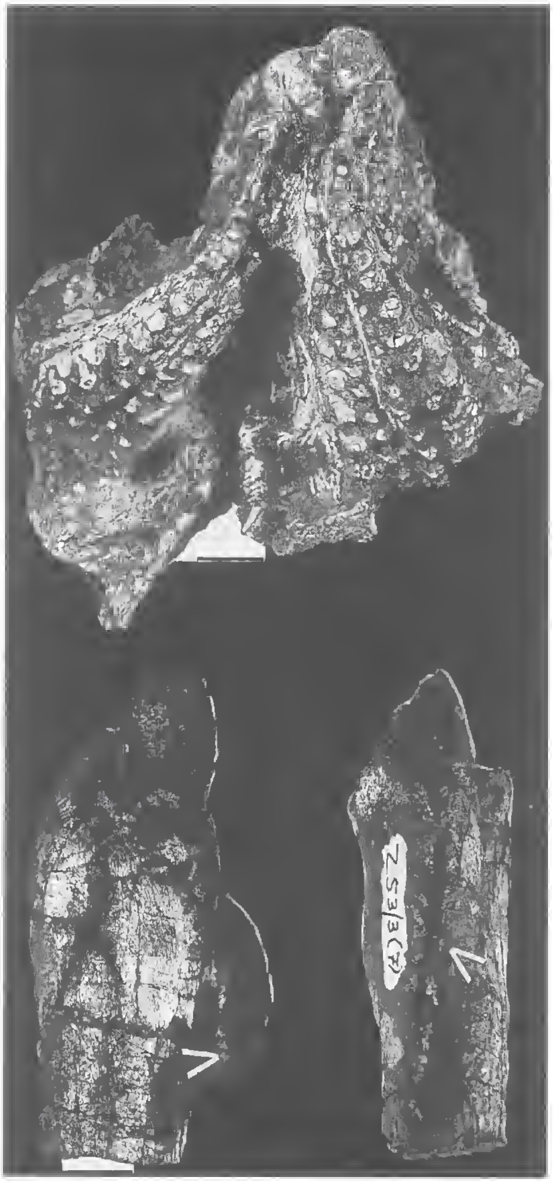

FIG. 3. Zimbabwean rhynchosaur locality. A, snout of a juvenile rhynchosaur, *Hyperodapedon*, in palatal view, showing the characteristic maxillary toothplates. B, fragmentary prosauropod left femur in lateral view; note crest-like fourth trochanter (arrowed). C, anterior surface of the femur in (B) showing the vascular groove (arrowed) leading to the nutritive foramen. Scales = 1cm.

Moreover, within a kilometre of the tracksite, and on a stratigraphic level either the same as or slightly above it, a finegrained shale outcrop contains abundant plant fossils dominated by the characteristic Molteno pteridosperm genus, *Dicroidium* (Fig. 2d).

No bones of dinosaurs are known from Molteno beds in South Africa, but they are certainly known from the higher levels of the Stormberg Group and its equivalents in many southern African localities (see Raath, 1980; Cooper, 1981; Kitching & Raath, 1984 and references therein); in fact, there are several good bone-producing sites in the Barkly Pass, within 50km of the Maclear tracksite.

The apparently consistent stratigraphic distribution of dinosaurs in the Stormberg led Kitching & Raath (1984) to propose the two biozones mentioned earlier — the *Euskelosaurus* Range Zone in the lower parts of the Elliot Formation, and the *Massospondylus* Range Zone in the middle and upper parts, extending into the base of the overlying Clarens Formation.

GROUP	FORMATION	DIVISION	BIOZONE
STORMBERG GROUP	Drakensberg Formation		[Lavas]
	Clarens Formation	Upper	
		Middle	
		Lower	*Massospondylus* Range-zone
	Elliot Formation	Upper	
		Middle	
		Lower	*Euskelosaurus* Range-zone
	Molteno Formation	Upper	New "pre-Elliot" dinosaur fauna
BEAUFORT GROUP			

FIG. 4. Summary of Stormberg stratigraphy in South Africa.

A complicating factor in the Maclear case is that the only dinosaurs so far known from the *Euskelosaurus* Range Zone are prosauropods — no theropods have been discovered to date. However, at least one theropod taxon, *Syntarsus*, is relatively common in the overlying *Massospondylus* Range Zone (Raath, 1980; Kitching & Raath, 1984). Tracks attributed to *Syntarsus* are known from Zimbabwe in beds which correlate with the upper Elliot Formation (Raath, 1972). In terms of general morphology, the Zimbabwe ?*Syntarsus* tracks are similar to the Maclear tridactyl prints, but *Syntarsus* is too small to have made the Maclear tracks. The identity of the track-maker therefore remains unresolved.

The conclusion that these tracks are in Molteno sediments also demands a reassessment of the validity of Ellenberger's (1970) stratigraphic assignments.

ZIMBABWEAN RHYNCHOSAUR AND DINOSAUR SITE. The rhynchosaur specimens and the prosauropod from Zimbabwe were discovered during mapping by P.M. Oesterlen of the Zimbabwean Geological Survey, in the Dande Communal Lands in the Lower Zambezi Valley during the late 1980s (Raath et al., 1992). The rocks exposed here range in age from late Palaeozoic to early Mesozoic (Broderick, 1984; 1989; Oesterlen, 1989) and the rhynchosaur material came from beds which Oesterlen mapped as Pebbly Arkose Formation (Fig. 5). This formation is of late Triassic age and is considered an equivalent of the South African Molteno Formation (Bond, 1973).

Chatterjee (1969; 1980) and Benton (1983) point out that rhynchosaurs fall into three family or subfamily groups whose stratigraphic distribution neatly coincides with the division of the Triassic into early, middle and late divisions. The subfamily Hyperodapedontinae is characteristic of, and apparently confined to, the late Triassic. Benton (1983) includes in this subfamily the East African form '*Supradapedon*', which comes from the late Triassic beds of Tunduru, Tanzania, and is very similar to the Zimbabwean form. On these grounds, the Zimbabwean rhynchosaurs are assigned to the late Triassic, and, by association, so is the dinosaur found with them.

A late Triassic (Molteno-equivalent) age for the Zimbabwean occurrences is further supported by the fact that, as in the South African case, the typical late Triassic plant genus *Dicroidium* is found in the vicinity of the Dande rhynchosaur localities, although so far not in direct stratigraphic association with the vertebrates.

It is therefore concluded that on stratigraphic and palaeontological grounds, the Maclear (South Africa) and Dande (Zimbabwe) sites show

Era	Period	Group	Formations in the Cabora Bassa Basin, Zimbabwe	South African Equivalents
Mesozoic	Cretaceous			[Post-Karoo]
	Jurassic		Dande Sandstone	
		Upper Karoo	Forest Sandstone	Stormberg Group
	Triassic		**Pebbly Arkose** (from which the rhynchosaurs and the dinosaur bone come)	
			Angwa Sandstone	

FIG. 5. Stratigraphy of Stormberg equivalents in Zimbabwe (adapted from Raath, Oesterlen & Kitching, 1992).

the presence of dinosaurs during Molteno times (?lower Carnian, Anderson & Anderson, 1984: 40) and, subject to a reassessment of Ellenberger's (1970) stratigraphic assignments, these are therefore the earliest indications of dinosaurs in this part of Central Gondwana.

ACKNOWLEDGEMENTS

I am grateful to the organisers of the Symposium on Gondwanan Dinosaurs, especially Fernando Novas and Ruben Cuneo for their invitation to take part and for their assistance which made it possible. Similarly I thank the Board of Trustees of the Port Elizabeth Museum, especially the Chairman, John Grieve, for releasing me to attend and for generous support of my trip. Finally I thank my colleague Nielen Schaefer and my friends and collaborators on the two projects discussed here, notably James Kitching, Phil Oesterlen, John Orpen and Gerald Spilkin for the many ways in which they helped.

REFERENCES

ANDERSON, J.M. & ANDERSON, H.M. 1984. The fossil content of the Upper Triassic Molteno Formation, South Africa. Palaeontologia africana, 25: 39-59.

BENTON, M.J. 1983. The Triassic reptile Hyperodapedon from Elgin: functional morphology and relationships. Philosophical Transactions of the Royal Society, London, B 302: 605-717.

BOND, G. 1973. The Palaeontology of Rhodesia. Bulletin of the Geological Survey of Rhodesia, 70: 1-121.

BRODERICK, T.J. 1984. A geological interpretation across a portion of the mid-Zambezi Valley lying between the Mkanga and Hunyani rivers, Guruve District. Annals of the Zimbabwe Geological Survey, 9: 59-79.

1989. An interpretation of the geology of the Cabora Bassa Basin, mid-Zambezi Valley. Annals of the Zimbabwe Geological Survey, 14: 1-11.

CHATTERJEE, S. 1969. Rhynchosaurs in time and space. Proceedings of the Geological Society, London, 1658: 203-208.

1980. The evolution of the rhynchosaurs. Memoires de la Societe geologique de France, N.S. 139: 57-65.

COLBERT, E.H. 1975. Early Triassic tetrapods and Gondwanaland. Memoires du Museum National d'Histoire Naturelle, N.S. A 88: 202-215.

COOPER, M.R. 1981. The prosauropod dinosaur *Massospondylus carinatus* from Zimbabwe: its biology, mode of life and phylogenetic significance. Occasional Papers of the National Museums of Rhodesia, B., Natural Sciences 6(10): 689-840.

ELLENBERGER, P. 1970. Les niveaux paleontologiques de premiere apparition des Mammiferes primordiaux en Afrique du Sud et leur ichnologie: Etablissement de zones stratigraphiques detaillees dans le Stormberg du Lesotho (Afrique du Sud) (Trias superieur a Jurassique). Pp. 343-370. In Haughton, S.H. (ed.) 'IUGS, 2nd Symposium on Gondwana Stratigraphy and Palaeontology'. (Council for Scientific and Industrial Research: Pretoria).

KITCHING, J.W. & RAATH, M.A. 1984. Fossils from the Elliot and Clarens formations (Karoo Sequence) of the northeastern Cape, Orange Free State and Lesotho, and a suggested biozonation based on tetrapods. Palaeontologia africana 25: 111-125.

OESTERLEN, P.M. 1989. The geology of the Dande West area (Western Cabora Bassa Basin) — a preliminary report. Annals of the Zimbabwe Geological Survey 14: 12-20.

OLSEN, P.E. & BAIRD, D. 1986. The ichnogenus *Atreipus* and its significance for Triassic biostratigraphy. Pp. 61-87. In Padian, K. (ed.) 'The Beginning of the Age of Dinosaurs'. (Cambridge University Press: Cambridge).

OLSEN, P.E. & GALTON, P.M. 1984. A review of the reptile and amphibian assemblages of the Stormberg of Southern Africa, with special emphasis on the footprints and the age of the Stormberg. Palaeontologia africana 25: 87-110.

RAATH, M.A. 1972. First record of dinosaur footprints from Rhodesia. Arnoldia (Rhodesia) 5(27): 1-5.

1980. The theropod dinosaur *Syntarsus* (Saurischia: Podokesauridae) discovered in South Africa. South African Journal of Science 76(8): 375-376.

RAATH, M.A., KITCHING, J.W., SHONE, R.W. & ROSSOUW, G.J. 1990. Dinosaur tracks in Triassic Molteno sediments: the earliest evidence of dinosaurs in South Africa? Palaeontologia africana 27: 89-95.

RAATH, M.A., OESTERLEN, P.M. & KITCHING, J.W. 1992. First record of Triassic Rhynchosauria (Reptilia: Diapsida) from the Lower Zambezi Valley, Zimbabwe. Palaeontologia africana 29: 1-10.

VISSER, J.N.J. 1984. A review of the Stormberg Group and Drakensberg Volcanics in southern Africa. Palaeontologia africana 25: 5-27.